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RADAR DIVISION

1 February 1962

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A MADRE EVALUATION REPORT (U)

DETECTION AND ANALYSIS OF AMR TEST 6210
(S)

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ABSTRACT

Portions of the trajectory of the Vertical Balloon, AMR Test 6210, were monitored with the Madre radar from Chesapeake Bay Annex. Detection was accomplished via direct look.

Post flight position data from AMR and the Madre data from the trajectory were combined to confirm the vertical pattern of the Madre antenna.

PROBLEM STATUS

This is an interim report on one phase of the problem; work is continuing on this and other phases.

AUTHORIZATION

NRL Problem R02-23
Project RF 001-02-41-4007

[REDACTED]

A MADRE EVALUATION REPORT
(UNCLASSIFIED TITLE)

DETECTION AND ANALYSIS OF AMR TEST 6210
[REDACTED]

For several months the Madre radar located at the Chesapeake Bay Annex of the Naval Research Laboratory has been used to detect missiles launched from the Atlantic Missile Range. In ordinary use, Madre's energy is refracted by the ionosphere (F layer) so that it illuminates the missile path close to the launch site and below-the-horizon detection can be obtained. Attempts to illuminate the launch site itself via the F layer during a launch have been unsuccessful to date because of the proximity of the Madre site to AMR launch sites. The combination of the current low sun spot period and the minimum frequency capability of Madre has resulted in placement of one hop energy beyond the site. However, whenever ionospheric conditions have been such that the missile path can be illuminated, successful detection of the exhaust has been accomplished from 80 km altitude on up. A line of sight path from the Madre site would place a beam about 130 km over the launch site.

Details of the Madre radar can be found in a number of publications. One of these is NRL Memo Report 1251, 1 Dec. 1961, "A Madre Evaluation Report," J. Headrick et al. For purposes of understanding the figures a partial description will be given here.

The receiver converts the received signals to a zero or near zero IF and these signals are passed through a set of comb rejection filters which reject the ordinary clutter by rejecting the repetition rate frequency and all of its harmonics plus a few cycles on either side of these frequencies. The doppler frequency from each target will appear around zero and around the repetition rate frequency and its harmonics. Also, although recede and approach dopplers can be resolved easily, it was not done for this test. Therefore, around zero and around the repetition rate frequency and its harmonics, both recede and approach dopplers will appear. For example, in Figs. 1 and 2 there can be seen the target doppler frequencies which are associated with zero frequency, 90 cps (the repetition rate) and 180 cps. Both approach and recede dopplers associated with the repetition rate are shown.

Advance information on Test 6210 indicated that the combination of the proposed launch time and the frequency limitations of the Madre radar would not permit placement of energy below the horizon near the launch site. Therefore, it was decided to forego an attempt to detect the booster and its exhaust and instead to attempt to detect the balloon directly in its trajectory. This would also afford a good opportunity to check the Madre vertical antenna pattern for the rotatable antenna via direct reflections from the balloon. The antenna consists of two colinear dipoles in a corner reflector. The only information available on its vertical pattern was from a series of measurements made on a scaled down model of the antenna taken from 450-900 mc/sec.

The pertinent parameters for the Madre radar during Test 6210 were as follows:

Frequency	26.6 mc/sec
Repetition Rate	90 pps
Power	100 KW average
Pulse Width	700 μ sec
Antenna Gain	15 db one way
Antenna Bearing	190° and 160°

There was no backscatter evident at this frequency and the ionograms indicated that refraction would be negligible below the electron density maximum.

Test 6210, otherwise referred to as "Big Shot" and A-12 Vertical Test, was launched on 15 January 1962 from Cape Canaveral at 6:07 AM, EST, on a 95° azimuth. It used a modified Thor missile as a booster. According to post-flight data received from AMR, booster cutoff came at To+141.6 secs at 161 km altitude. Vernier engine cutoff came at To+152.6 secs at 210 km altitude. The balloon was ejected, inflated and rose to a maximum height of 1505 km. On return to earth a capsule was ejected from the booster at To+22 minutes and 57 seconds at 310 km altitude about 500 n.m. down range.

The balloon was supposed to inflate to 135 ft. diameter. According to newspaper accounts, the balloon broke into three or more pieces on inflation. No knowledge of the sizes, shapes or dispositions of the various pieces has been obtained other than those from sketchy newspaper accounts.

The data presented here were taken from the output of the comb filters and recorded on magnetic tape. A Kay Vibralyzer was then used to analyze the tape. The Madre system also employs a real time analysis system which was in operation during the test. Since it would not substantially add to the results obtained, it will not be presented here.

Figures 1 and 2 are the complete record of the doppler versus time information that was obtained during the test. 90 cps was the repetition rate. The thick black line between 90 cps and 180 cps indicates the doppler record calculated from the AMR post-flight data and referred to the Madre site. The corresponding line between 0 and 90 cps is the doppler record made at the Madre site during the test.

Two points should be made. First, whenever the target has a doppler corresponding to the repetition rate frequency or one of its harmonics, it disappears into the rejection notch. Secondly, the regular fading out of the target in between the repetition rate notches is due to the presence of the target into one of the antenna pattern nulls. Referring to Fig. 1, the missile was first detected at To+139 secs when the booster cutoff was observed. This is the usual pattern observed for a Thor missile cutoff. The track of the vernier engine can be faintly seen disappearing into a rejection notch. During the times of the vernier

cutoff and balloon ejection, the target was in this notch, so neither of these events were observed. These notches have depths to 80 db.

At about To+170 secs, the target emerges from the notch and is observed continuously, except for fading until To+349 secs where it is very weak. Post-flight data give the height at this time at 915 km. The system calibration signal is present from To+160 to To+280 at about 30 cps.

The system was shut down at To+350 secs so that the antenna could be moved to 160° azimuth.

Figure 2 is the doppler versus time record of the return of the target toward earth. It was first detected at To+1217 secs and was observed continuously except for fading until To+1420 secs. During this time, two targets are always present, and occasionally a third target appears. Preflight data places the balloon and booster trajectories fairly close in time and range as observed from the Madre site. At present it is not known whether the post-flight data obtained from AMR represents the booster or the balloon trajectories. From the data it cannot be ascertained whether the targets observed by Madre represent pieces of the balloon or the balloon plus the booster. It is felt, however, that the Madre data must represent pieces of the balloon since the booster is a relatively small target and cannot be expected to be detected with the energy levels which exist in the higher angles of the antenna pattern.

At To+1377 secs a capsule was ejected from the booster to be recovered. This event was not observed possibly because the target was in a rejection notch at the time or perhaps because the event did not produce a large enough signal.

Between To+1400 and To+1420 secs the targets are seen to decelerate and oscillate a little. This peculiar pattern of behavior has been observed previously on the Madre radar in connection with the reentry of large unsymmetrical bodies traveling at velocities close to those of the balloon pieces or the booster.

The system calibration signal is present from To+1380 to To+1440 at about 20 cps.

Figure 3 is a representation of the target geometry with respect to the Madre radar site. The times and heights are taken from the postflight data from AMR. The solid black lines in the trajectory represent the times when the target was being observed by Madre. The spaces in between represent the times when the target faded or went into a rejection notch. The slant range, as measured by Madre, corresponds to the ranges shown within the range resolution capability permitted by the 700 μ sec pulse width.

Superimposed upon this geometry is the vertical antenna pattern as measured on a scaled down model at 900 mc/sec. This would correspond to 27 mc/sec for

the full size antenna. It can be seen that the target data fit the geometry of the simulated pattern very well.

There are three things to be noted here:

First, postflight data from AMR do not include the time from To+1217 secs to To+1260 secs, so a dotted line has been placed in this region to indicate that the target was detected by Madre at that slant range but that its position was not given.

The second point to be noted is in the segment from To+1400 secs to To+1420 secs. It is shown as a black line because AMR gave this position in the postflight data. However, since the Madre data shows definite deceleration of the targets prior to To+1420 secs, it is very doubtful if the AMR radar and Madre radar were tracking the same targets. The Madre-detected targets most probably were not as low as Fig. 3 indicates when they faded out for the last time.

The third point to be noted is unquestionably connected with the second point. In the segment from To+1320 secs to To+1330 secs on Fig. 3, it can be seen that the target suddenly jumps in range. Since this plot was made from the position data given by AMR, the only conclusion is that the AMR radar suddenly locked onto a new target. By sighting along the return trajectory it can be seen that the target acts normally until To+1320 secs. Then it jumps in range with respect to the Madre site and acts normally during the rest of the time, but at the new range. There is no known force on the balloon that could cause this and furthermore the Madre range data, which is not shown here, shows nothing unusual happening at this time. This gives some support to the second point previously mentioned.

A preliminary analysis of the amplitude data indicates that the power envelope, as indicated in Fig. 3, roughly follows the scale model measurements, but that there may be more energy in the higher angle lobes of the antenna than is indicated. This study is not yet complete.

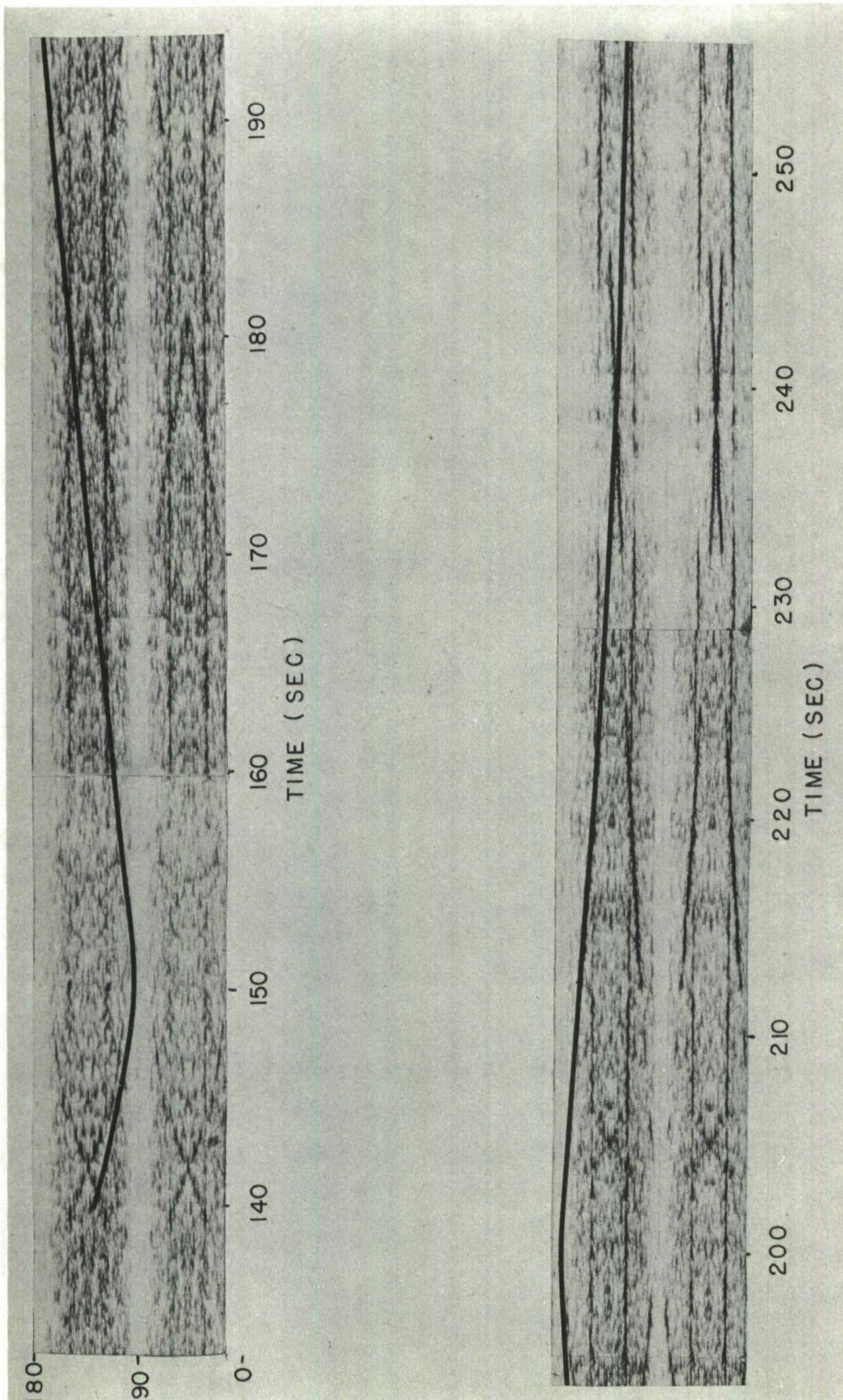


Fig. 1a - Vibrogram record of the doppler frequency versus time after launch of Test 6210 during ascent. The pulse repetition rate was 90 cps. The blank at 90 cps is the result of the rejection filters. The 60 cps signal throughout is due to the equipment.

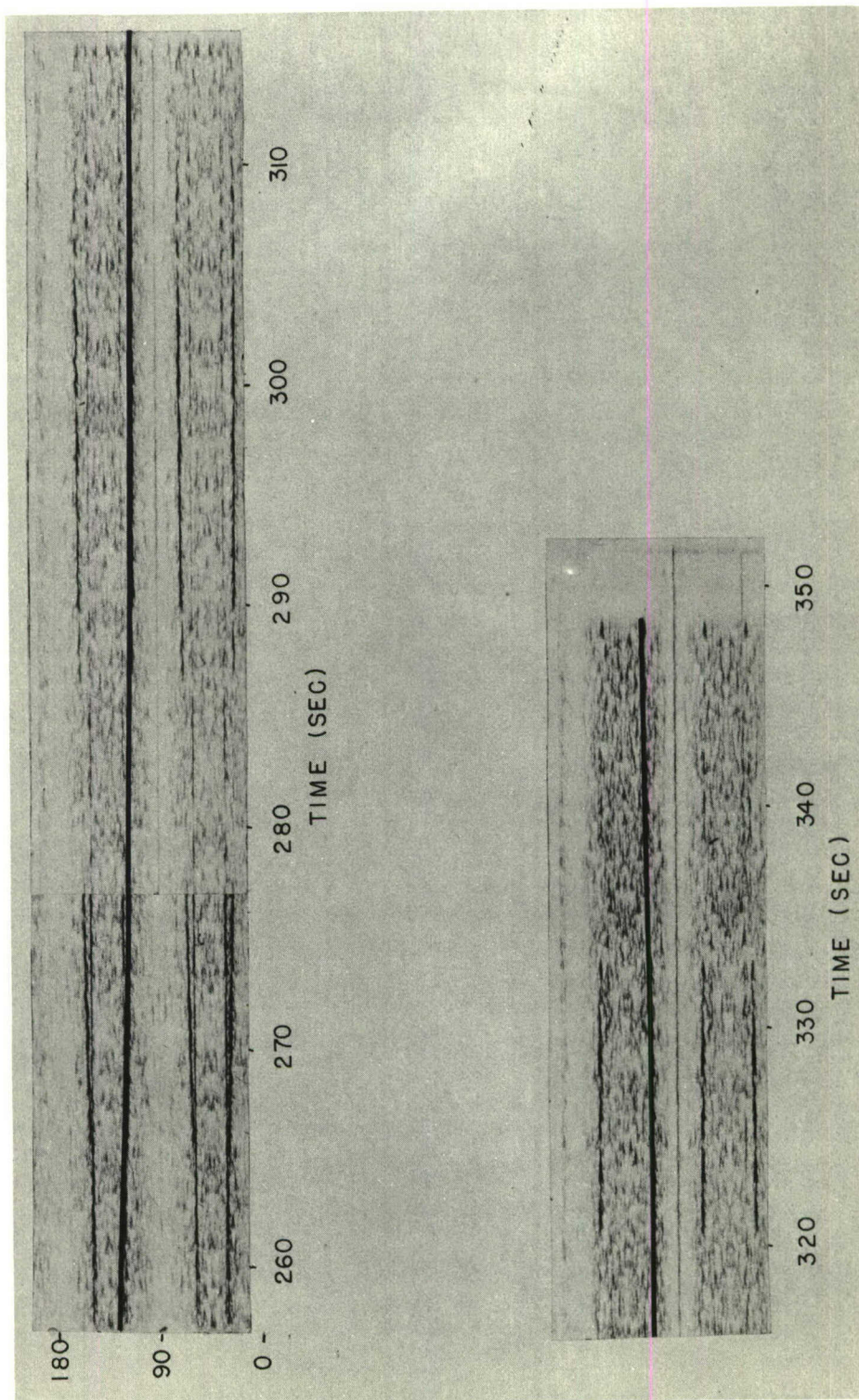


Fig. 1b - Continuation of Fig. 1a

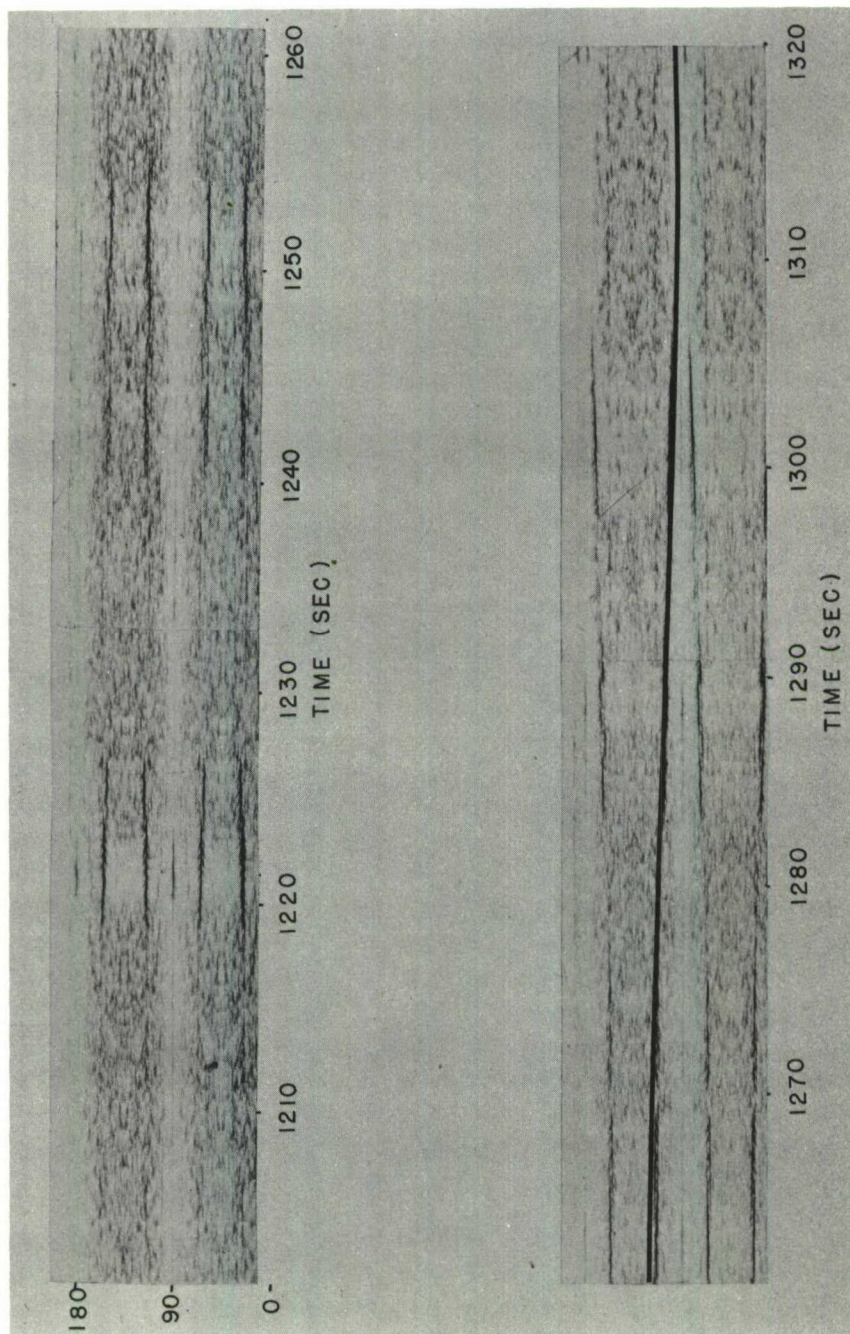


Fig. 2a - Vibrogram record of the doppler frequency versus time after launch
of Test 6210 during descent

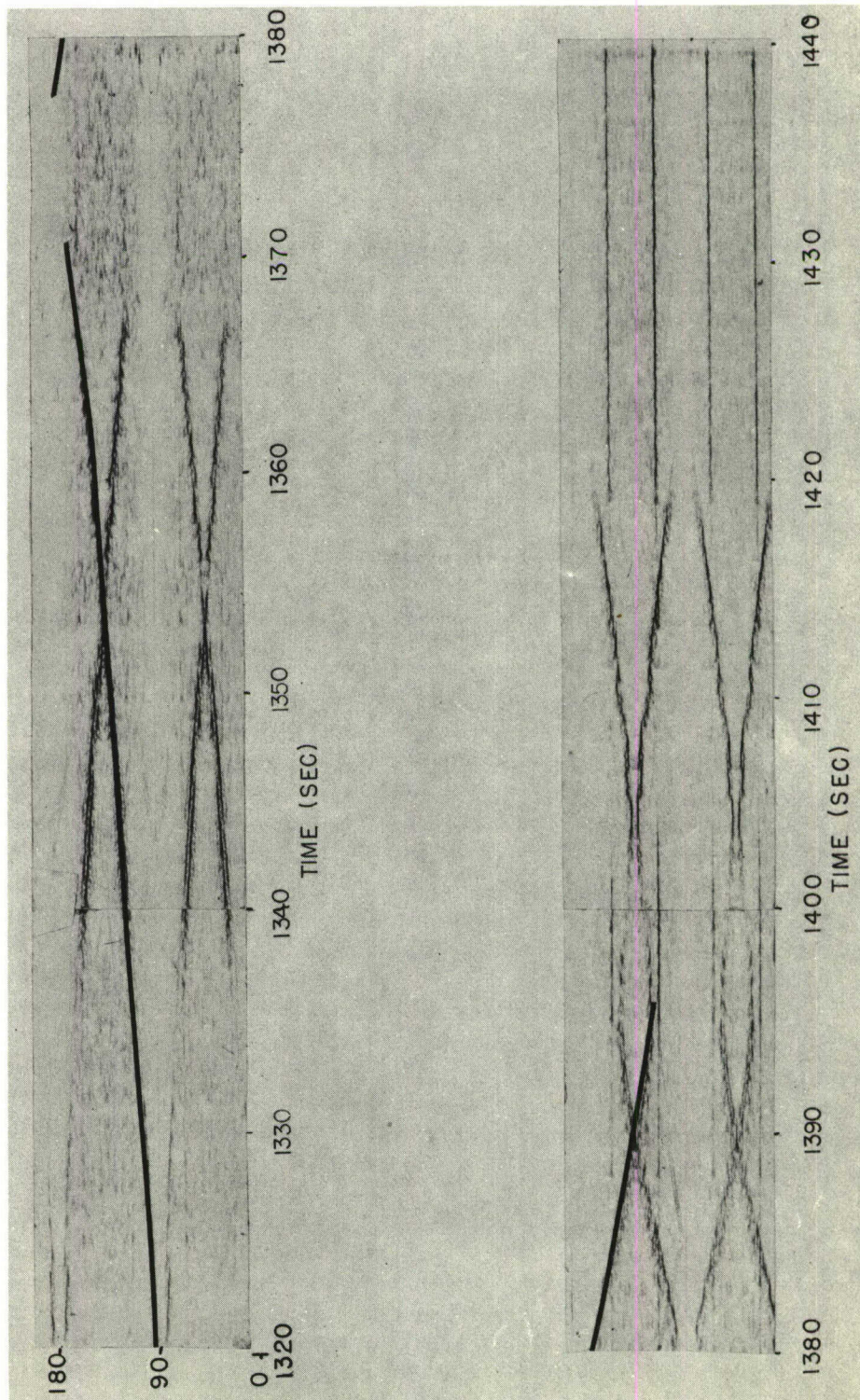
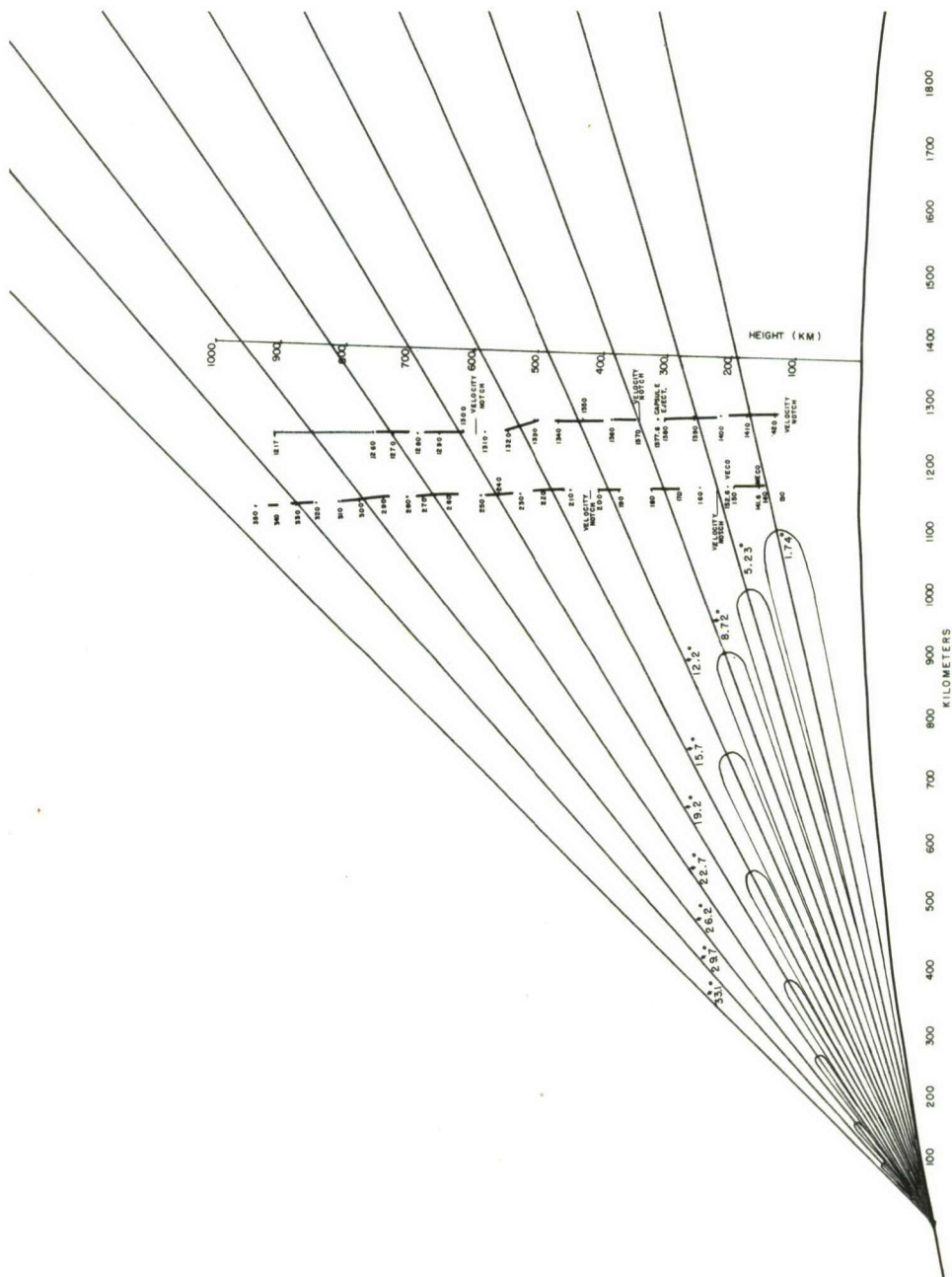


Fig. 2b - Continuation of Fig. 2a



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